Systematic investigation of dineutron correlation in light neutron-rich nuclei(Digest_要約)

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In this thesis, we investigate dineutron correlation in the light neutron-rich nuclei. A dineutron means a spatially compact spin-singlet pair of two neutrons, which can be regarded as a kind of cluster. Two neutrons in free space are not bound so that the dineutron features changes readily and greatly depending on the circumstance. Dineutron correlation has been discussed for a few neutron-rich nuclei but possible diverse dineutron features have not been known at all. For instance, how does the degree of dineutron formation, the degree of dineutron expansion from a core, and dineutron size depends on the circumstances such as occupied orbits by core nucleons, core deformation, and strength of binding between a core and valence neutrons? Additionally, do compact dineutrons which may be regarded as a cluster form cluster condensation (which means that some identical clusters occupy the lowest-S wave simultaneously and is characterized by a gaslike structure of those clusters expanded widely with little correlation)? Our purpose is to make clear the universal properties of dineutron correlation through the systematic investigation of many neutron-rich nuclei. We constructed a model, a dineutron condensate wave function, to closely describe the dineutron motion about a core under considering core structure change. Using this framework, we mainly investigate dineutron correlation in the ground and excited states of neutron-rich p-shell nuclei and discuss the dineutron features depending on the nuclear structure in those nuclei. First, taking a $2\alpha + 2n$ system as an example, we calculate the $2n$ energy about the 2α core by using a dineutron condensate wave function to examine how large size and expansion from the core the spin-singlet pair of two valence neutrons favors energetically. We show that a compact dineutron is energetically favored at the nuclear surface. The key to the mechanism of compact dineutron formation is the Pauli repulsive effect and the attraction between the valence neutrons and the core nucleons. Owing to such a mechanism, a compact dineutron can be generally formed at the surface, at least in the ground states of p-shell nuclei. Subsequently, we investigate dineutron correlation in the ground states of ^{10}Be and ^{9}Li, that is, dineutron correlation about an $\alpha+\alpha$ and $\alpha+t$ core, respectively, by using a kind of cluster wave functions and dineutron condensate wave functions. We take into account core cluster breaking in these wave functions and we consider the effect of core structure change on dineutron correlation. The degree of dineutron formation significantly depends on core structure, because a dineutron is fragile and readily dissociated to two independent neutrons in the major shell due to the spin-orbit interaction from the core. We suggest that the core structure and the occupied orbits by core nucleons strongly affect the degree of dineutron formation. We also investigate diproton correlation in the ground states of ^{9,10}C, which are the mirror nuclei of ^{9}Li and ^{10}Be, respectively, and compare the diproton features in ^{9,10}C with the dineutron features in ^{9}Li and ^{10}Be. We find that there are no qualitative differences between dineutron and diproton correlation for these nuclei which are not extremely loosely bound nuclei. This is because the core effect, which is the basis of dineutron formation, is much stronger than the Coulomb repulsive effect between two protons so that strong diproton correlation can be realized in

the surface region as well as dineutron correlation. Next, we investigate cluster excitation for ^{10}Be by using cluster wave functions and dineutron condensate wave functions to mainly describe cluster structures in ^{10}Be. We suggest two kinds of exotic cluster excited states which have not been experimentally confirmed yet: The one has a gaslike structure of two α and one dineutron clusters which are weakly interacting with each other and widely expanded. The other has ^{6}He and an extremely developed α cluster. These states are supposed to exist in the close energy region but have distinct structures from each other so that we suggest that these states can be confirmed by different observables. The former state would have a remarkable monopole transition strength because of the large spatial expansion of two α and one dineutron clusters. The latter state would have a large α decay width because an α cluster is extremely developed in this state. We discuss the structure of each cluster excited state and the promising observables to establish those states experimentally. Finally, We focus on ^{8}He which is well described with an α core plus four valence neutrons. For ^{8}He, it is naively expected that four valence neutrons occupy the $0p_{3/2}$ orbits independently and form $0p_{3/2}$ subshell closure, but it is also expected that one or two dineutrons can be formed in the neutron-skin region. We superpose cluster wave functions and dineutron condensate wave functions which efficiently include those shell-model and dineutron configurations to describe ^{8}He and we investigate the contribution of those components to the ^{8}He ground state. We clarify that the $(0p_{3/2})^4$ shell-model component and one-dineutron component far from the core are mixed in the ^{8}He ground state. The component of two dineutrons expanded from the core is minor in this state since four valence neutrons are moderately bound to the core and the dineutron dissociation due to the spin-orbit force from the core is significant. We compare the dineutron component in the ^{8}He ground state with that in the ^{6}He ground state (an α core plus two valence neutrons). The dineutron component is enhanced in ^{6}He compared with ^{8}He because ^{6}He is extremely loosely bound system of $\alpha + 2n$ and the dineutron dissociation becomes less effective in this state. Additionally, in the ^{8}He excited state, we suggest the possibility of the two-dineutron condensation in which two compact dineutrons with the same size occupy the same S orbit and are widely expanded around an α core with little correlation. We show that the moderate attraction from the core is the essential for the formation of dineutron condensation. We conclude that dineutron correlation can be significant more or less to describe the ground and excited states of neutron-rich nuclei, though the dineutron features can change largely depending on the circumstances. Moreover, we conclude that a dineutron can behave as a kind of quasi-boson and dineutron condensation can be realized in finite nuclei.